Bank Protection of Yellowstone River, Near Huntley, Montana

by Dudley Frank Black

1910

Submitted to the School of Engineering of the University of Kansas in partial fulfillment of the requirements for the Degree of Master of Arts

BANK PROTECTION of YELLOWSTONE RIVER NEAR HUNTLEY MONTANA

DUDLEY F. BLACK

1910

This Thesis submitted with application for the

Degree of Civil Engineer.

June 1910.

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By

Dudley F. Black.
Class of 1904.

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BIBLIOGRAPHY.

In the design of the following described bank protection works, credit should be given a book written by B. F. Thomas, Member of the American Society of Civil Engineers, and D. A. Watt, Member of the American Society of Civil Engineers, published in 1909 under the title of "The Improvement of Rivers. A Treatise on the Methods Employed for Improving Streams for Open Navigation and for Navigation by means of Locks and Dams" by John Wiley & Sons, New York. See page 63.

BANK PROTECTION OF YELLOWSTONE RIVER NEAR HUNTLEY MONTANA.

HISTORY. Huntley, Montana is a thriving little town less than three years old situated on the south bank of the dashing Yellowstone River at the junction of the Burlington and Northern Pacific railroads. The United States Reclamation Service laid out the townsite and the money derived from the sale of lots, with the exception of a small amount paid by the government to the Crow Indians, went to increase the Reclamation Fund. On the opposite side of the river is a high bench about five miles wide and extending for miles up and down the river. This bench was irrigated by a corporation under the Carey Act, became thickly populated, and being tributary to Huntley, made it necessary for the county to build a bridge over the river. The sight on which the bridge was built was bad in one respect because the south bank of the river, at that point, is low and subject to overflow during high water. Across this low land an earth fill was made twenty-seven hundred feet long ranging from sixteen feet in height at the bridge abutment to nothing at the end. This fill is not straight but makes a bend conforming to a bend in the river and runs more or less parallel to the bank of the river. Due to a change in the channel above, the river

began cutting its banks in this bend and, as the Yellowstone is a swift river, running about nine feet a second or a little more than six miles an hour during low water, it cut this bank back over two-hundred feet in two years and began cutting the road fill. During this time, the importance of doing something was fully realized by the townspeople of Huntley but, as there were no funds available for the town's expenditure and as the town was too small to undertake raising much money by subscription, their hands were tied. If the river had been allowed to cut through the road fill during high water, it would probably have cut a new channel leaving the county's forty-thousand dollar bridge off to one side. To prevent this, the County Commissioners decided to riprap about a thousand feet of the river bank and to construct five short wing-dams of stone and brush extending out into the stream forty feet. (Fig.1 page 10) Accordingly bids were advertised for under the following specifications.

SPECIFICATIONS.

Yellowstone River Improvement at Huntley Montana.

The work under these specifications consists in constructing five stone and brush wing-dams, the sloping of river bank, and placing about nine-hundred feet of brush and stone riprap on the sloped bank. Besides this, which shall be called"Wet Work", there is to be constructed a brush and stone dike about one-hundred and fifty feet

long across a slough that is dry except at high water and the placing of one-hundred feet of brush and stone riprap on the upper side of the earth fill road immediately adjacent to the east abutment of the bridge over the Yellowstone River; this to be called"Dry Work."

A. METHOD OF CONSTRUCTION. All work shall be done in conformity with the instructions of the engineer, and the stakes set by him, and in accordance with the following specifications and the accompanying plans which are hereby made a part of these specifications. (Fig.1 & 2 page 10 & 12)

B. INTERPRETATION OF PLANS OR SPECIFICATIONS. In case of doubt as to the interpretation of plans or specifications, the decision and instructions of the engineer shall be accepted as final.

C. WING-DAMS. The wing-dams shall be constructed of alternate layers of willow or brush mattresses and stone. Each layer to be one foot in thickness and placed as shown in plans. On the downstream side of each wing-dam shall be placed an apron of such dimensions as shown in the plan, consisting of one layer of brush and stone similar in construction to, and contiguous with, the wing-dam. The crest of each wing-dam shall be approximately at the same elevation as the adjacent bank of the river.

D. CONTINUOUS BANK PROTECTION. The bank between wing-dams and as indicated by the engineer, after being sloped from the bed of the stream to a slope of 1 1/2 : 1 according


Bar
WEST CHANNEL
Gravel Bar
SLOUGH
Rim Rocks
ISLAND
NORTH
BRIDGE
CHANNEL
Bar
MAIN
Gravel Bar
Gravel Bar
NORTH LINE HUNTLEY TOWNSITE
Rip-Rap
HUNTLEY
Brush & Rock Dam
SLOUGH
Bank Rip-Rap
Wing-Dam
Bar
County Road Fill
TOWNSITE
YELLOWSTONE RIVER
SHOWING
Bank Protection near HUNTLEY MONTANA
SCALE
0 100 200 300 400
Dudley F. Black, Dec. 1909.

10.

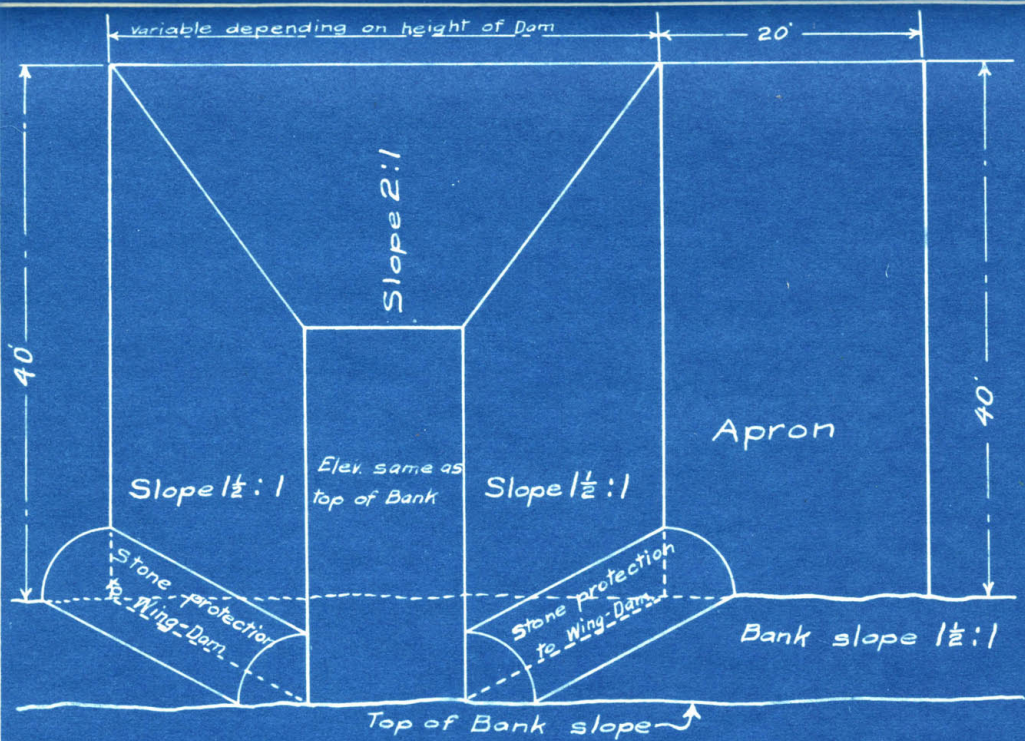
Fig. 1.

to stakes set by the engineer, shall be covered with a continuous mat of brush extending beyond the foot of the bank slope at least five feet out on the bottom of the river. This mat to be one foot in thickness and covered with a layer of stone one foot in thickness.

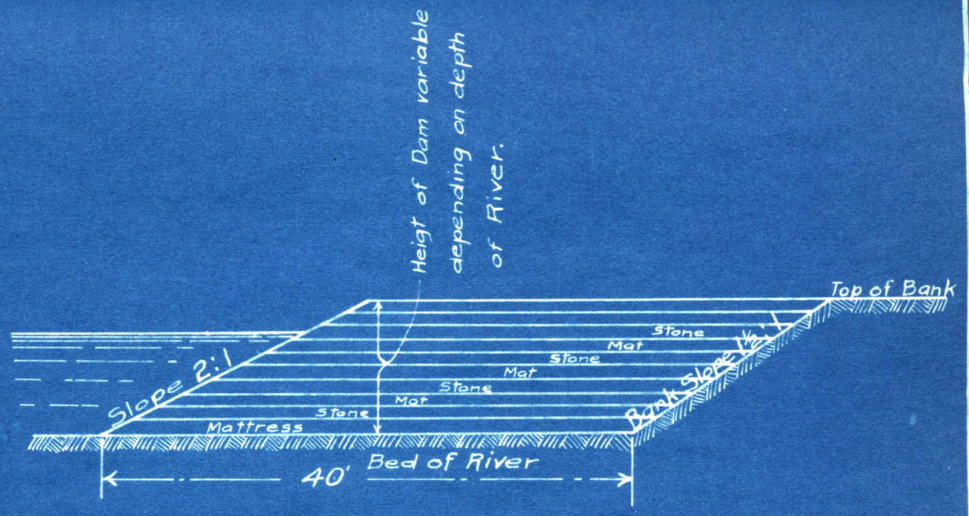
E. STONE. The stone shall be of suitable quality such as that in the stone cliffs south of Huntley. In size it shall be one man stone with enough smaller stones or spalls to fill the spaces between the larger ones.

F. BRUSH. No brush is to be over three inches in diameter at the butt. All brush shall be tightly bound with wire into bundles one foot in diameter. Each bundle shall have three wires around it; one at each end and one in the middle. In making mattresses, the separate bundles are to be held in place with poles and wire until sunk in place and covered with stone. Brush shall be laid with butt ends down stream in wing-dams and with brush end in the water on the bank.

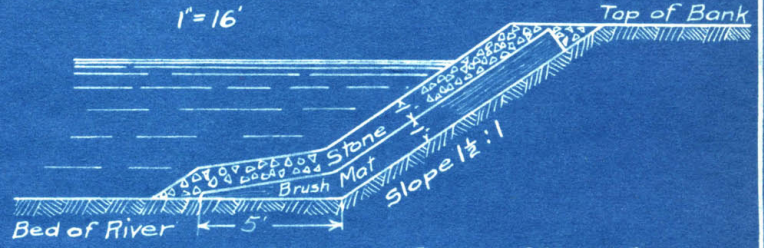
G. BIDS. Bidders will submit bids on the work per cubic yard of stone and brush in place called"Wet Work" and per cubic yard of stone and brush in place called "Dry Work." Each bidder is required to submit a certified check for five-hundred dollars with his bid which is to be forfeitted in case his bid is accepted and he fails to enter into contract with the county according to his accepted bid. Certified checks will be returned to all



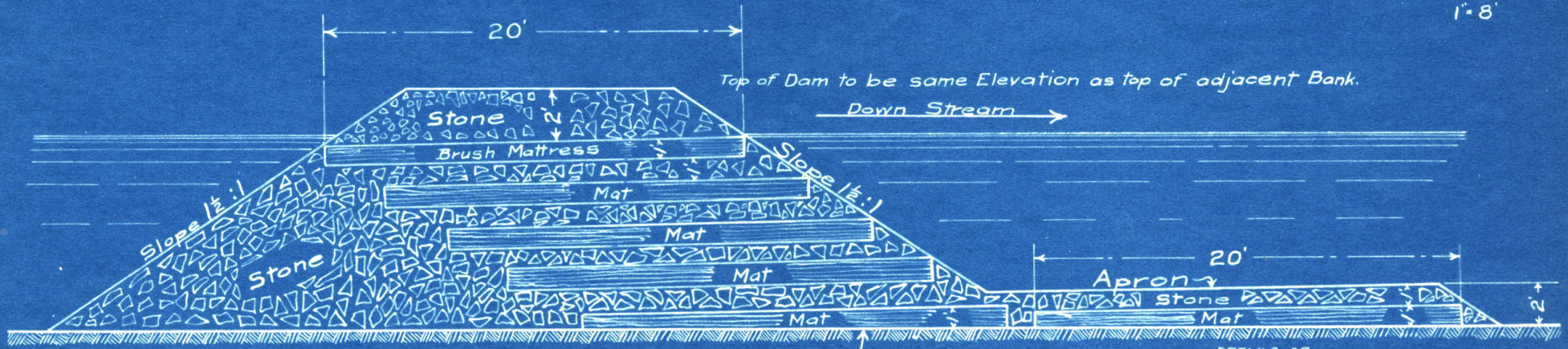
PLAN OF WING-DAM & APRON.
1" = 16'



SIDE ELEVATION OF WING-DAM.
1" = 16'



SECTION OF BANK PROTECTION.
1" = 8'



SECTION OF WING-DAM & APRON.
1" = 8'

DETAILS OF
WING-DAMS & BANK PROTECTIN
FOR RIVER IMPROVEMENT NEAR HUNTLEY MONTANA. December 1909.

Dudley F. Black.

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Fig. 2.

unsuccessful bidders, and also to the successful bidder after he has entered into contract with the Board of County Commissioners and furnished bond for four-thousand dollars guaranteeing the completion of the contract to the satisfaction of the Board of County Commissioners by April 15, 1910.

H. INSPECTION.The work shall, at all times, be subject to the inspection of the engineer, or his representative.

LETTING OF CONTRACT.

Bids were opened on December 30, 1909, the lowest and accepted bid being at the following prices;

2.65 per.cu.yd. for all Wet Work in place.

2.20 per cu.yd. for all Dry Work in place.

.50 per cu.yd. for dirt excavation in sloping banks.

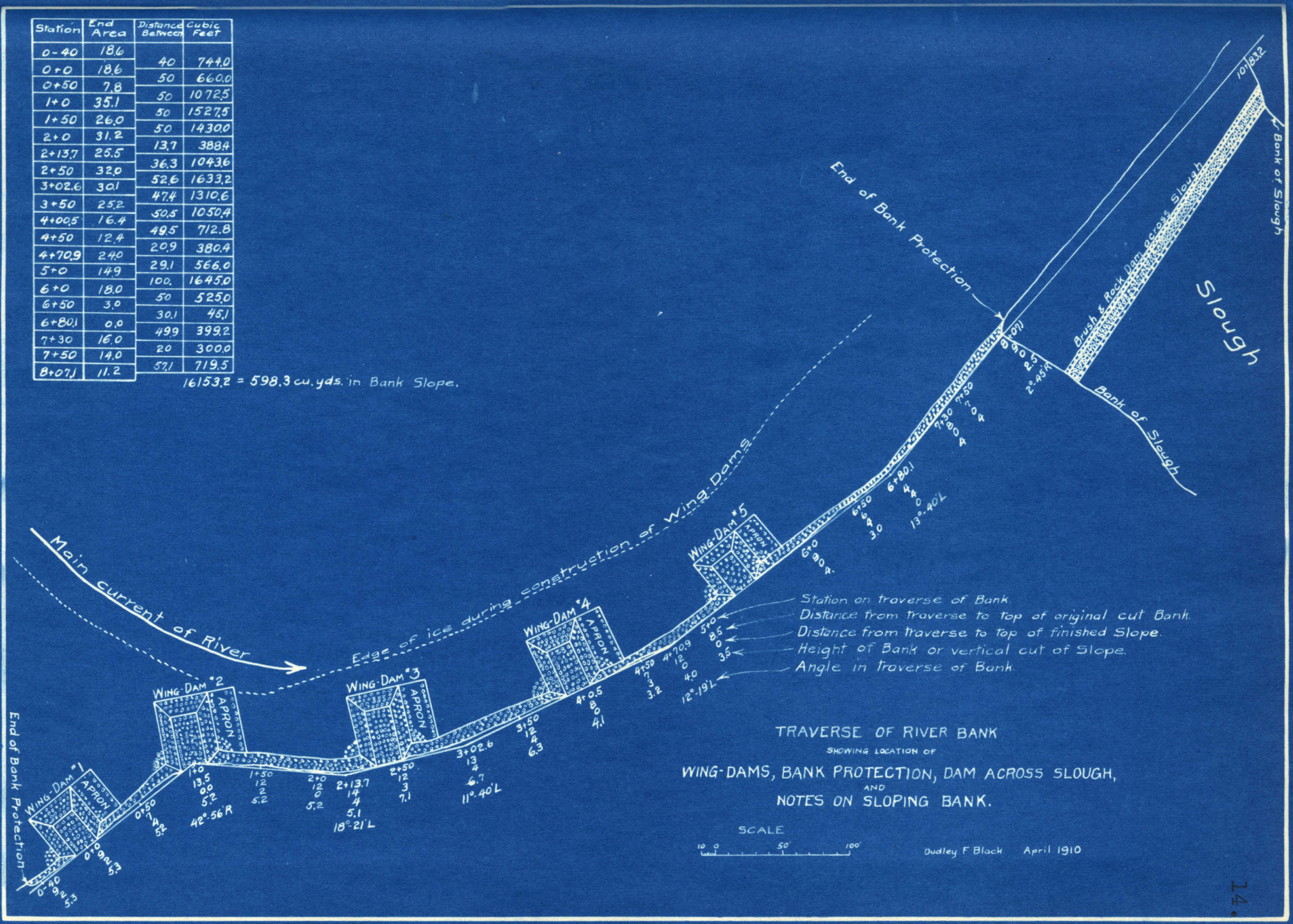
The contractor entered into a satisfactory contract with the Board of County Commissioners, assembled his camp and equipment, and began quarrying stone and cutting brush on January 6,1910.

WEATHER.

Weather conditions were most favorable for the contractor during the construction period and this fact alone was a very important factor in deciding the profits on the contract. The winter was quite cold and, by the time the contractor began construction, there was a sheet of ice sixteen inches thick and from fifty to sixty feet wide all along the river shore. (Fig.3 page 14) This ice

Station	End Area	Distance Between	Cubic Feet
0-40	18.6		
0+0	18.6	40	744.0
0+50	7.8	50	660.0
1+0	35.1	50	1072.5
1+50	26.0	50	1527.5
2+0	31.2	50	1430.0
2+13.7	25.5	13.7	388.4
2+50	32.0	36.3	1043.6
3+02.6	30.1	52.6	1633.2
3+50	25.2	47.4	1310.6
4+00.5	16.4	50.5	1050.4
4+50	12.4	49.5	712.8
4+70.9	24.0	20.9	380.4
5+0	14.9	29.1	566.0
6+0	18.0	100.	1645.0
6+50	3.0	50	525.0
6+80.1	0.0	30.1	45.1
7+30	16.0	49.9	399.2
7+50	14.0	20	300.0
8+07.1	11.2	57.1	719.5

16153.2 = 598.3 cu. yds. in Bank Slope.



TRAVERSE OF RIVER BANK
SHOWING LOCATION OF
WING-DAMS, BANK PROTECTION, DAM ACROSS SLOUGH,
AND
NOTES ON SLOPING BANK.

SCALE
10 0 50 100

Dudley F. Black April 1910

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Fig. 3.

proved to be a great advantage in constructing the wing-dams as it gave the contractor something to work on and made it unnecessary to have any barges or pontoons.(Fig.4 page 16) Besides this, it cut out the current of the river which is quite swift, and gave the contractor still water to sink his mattresses in instead of a swift river current. The cutting out of the current was partly due to slush and floating ice packing under the sheet ice,where it was some places packed to the bottom of the river. After constructing the wing-dams, the contractor did the Dry Work and, while he was doing that, the spring thaw came, the ice went out of the river, and the frost left the ground. This made it possible for the contractor to slope the banks with shovels and slips without using powder, as would have been necessary had the frost remained in the ground. Moreover, the weather was such that the contractor lost only two half days on account of storms, besides three days lost due to an ice jamb.

WING-DAMS.

The wing-dams were constructed in the following order 5, 1, 2, 3,&4. No.5 was in water ranging from three feet deep at the bank to nine feet at the end. No.1 was in water ranging from three feet to six. No.2,3,and 4 were built in water ranging from three feet to eleven feet deep at the outer end. In preparing for the construction of a wing-dam,first the bank was sloped, then a block of ice

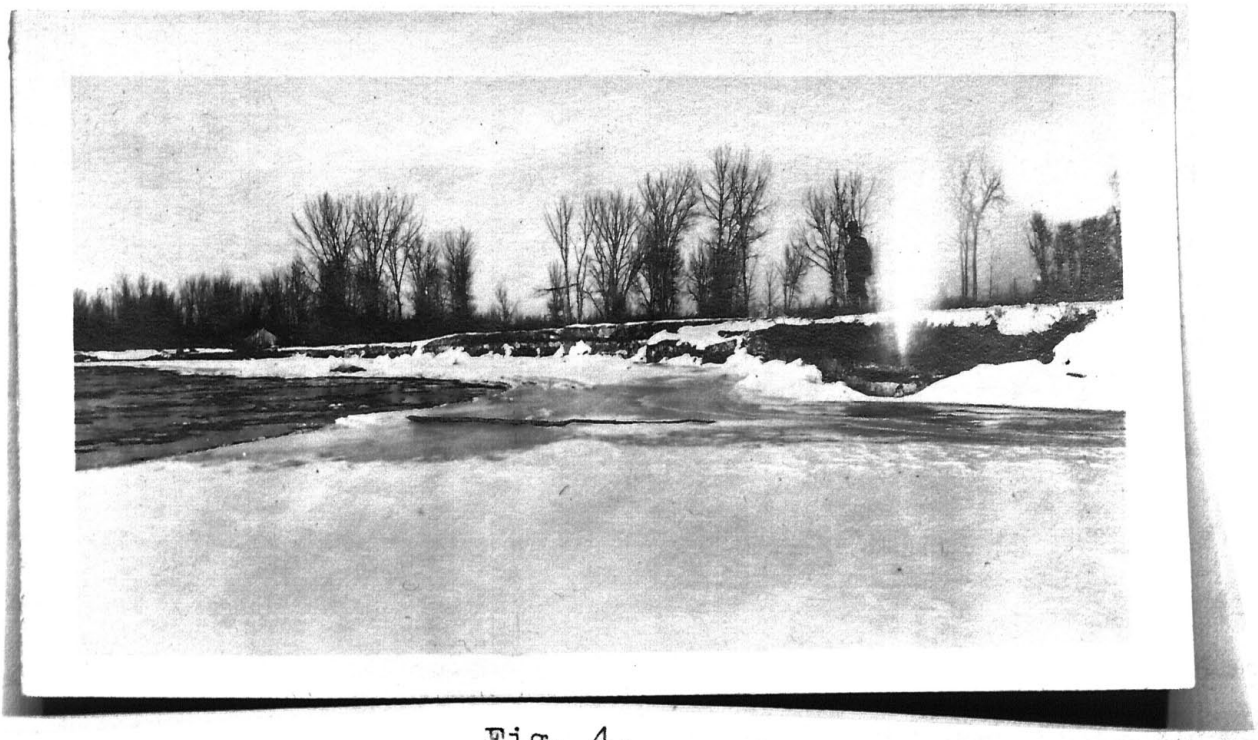

Fig. 4.

View taken Jan.14,1910 showing condition of bank and sheet of ice at location for wing-dam No.2, looking north.

Fig. 5.

View taken Jan.31,1910 showing preparation for construction of wing-dam No.2. Tripods and poles in place.

was sawed out the size of the bottom of the wing-dam and apron, forty by sixty feet. (Fig.5 page 16) This block of ice was broken up with powder and floated out to and down the channel of the river. The contractor had two tripods made of six by six timbers eighteen feet long, with iron spikes on two legs to keep them from slipping on the bottom of the river. He placed these tripods thirty-five feet out from the bank with a forty foot telephone pole resting between them. Two other telephone poles of the same length rested on the bank at one end and out over the first mentioned pole at the other end. (Fig.5&6 pages 16 & 18) The mats were made by first placing three cottonwood poles about eight and one half feet apart with their butt ends out over the telephone pole between the tripods. The brush bundles averaged about twelve feet long, the longer ones being saved for the bank protection, and these were placed on the three cottonwood poles, overlapping eachother on the middle pole. (Fig.7 page 18) After sufficient number of brush bundles were in place to make a mat of the desired thickness, three other cottonwood poles were placed over the first three, each pole being wired every three feet to the pole under it. (Fig.8 page20)The ends of the bottom poles were then cut off allowing the mattress to fall into the water. The wires between the upper and lower poles were then tightened up as much as they would safely stand, after which the mattress was ready to sink in place.

Fig.6.

View taken Jan.31,1910 showing the first mat in wing-dam No.2 sinking into place,also method of handling stone with barrows.

Fig.7.

View taken Jan.19,1910 showing method of constructing a mat. Wing-dam No.5.

The stone was dumped on the bank, and from there, carried out over a gang-plank on two telephone poles in wheelbarrows and dumped in place. (Fig.6 page 18) The gang-plank was moved over,as was necessary,until the desired amount of stone was in place,after which another mat was made as before, keeping the desired slope on the sides and end of the wing-dam.

BANK PROTECTION.

In constructing the continuous bank protection, first the bank was sloped, then the mat was made by laying the brush in place with butts on the bank and tops out in the stream. This brush ran from sixteen to twenty feet long. Around every three bundles was placed two wires, one at the water's edge and the other near the butts. There were then two lines of poles placed corresponding to the wires and each wire was drawn tightly around its inclosed bundles of brush and pole. Adjoining poles were overlapped and wired together making one continuous mattress for the bank. (Fig.9 page 20) The stone wagons drove to the top of the bank slope and unloaded onto the mat. The stone was then rolled down and placed by hand, making the slope smooth and uniform.

DRY WORK.

The protection to the first one hundred feet of road fill,adjacent to the east abutment of the bridge,was the same kind of construction as the bank protection with the exception that no sloping of bank was necessary and there

Fig. 8.

View taken Jan.19,1910 showing mat ready to be let down into the water. Wing-dam No.5.

Fig. 9.

View taken Mar.28,1910 showing bank mat before it was covered with stone, looking north from wing-dam No.3.

was no water to contend with.(Figs.11 & 12 pages 22 & 24) The reason that this work was done was that, during the high water of June 1909, the fill cut at this point immediately behind the abutment where it was cut back for six or eight feet.

The dike across the slough (Fig.13 page 24) consisted of a layer about one foot thick of sixteen foot brush bundles wired to two lines of poles, same as the bank protection. On this mattress was placed a layer of stone ranging from two to four feet thick.

PROGRESS OF WORK.

The contractor began work January 6th. Work on wing-dam No.5 began January 13th. On January 18th. the contractor began sloping bank for wing-dam No.1. January 26th. work was begun on wing-dam No.2. February 2nd. No.3 was started. February 12th. No.4 was started. March 2nd. the contractor began on protection to the road fill adjacent to the bridge abutment. On the afternoon of March 5th. the ice jambed in the river which raised so that the contractor had to cease work. (Fig.14 page 26) He began shooting out the jamb Sunday morning March 6th. and the ice went out about noon Wednesday March 9th. From this time on, the weather got warm and the frost left the ground. On March 15th. work was begun on the bank slope. April 8th. work began on dike across slough, and the contract was finished April 13th. Figs. 15, 16, 17, 18, and 19 are views of the finished works

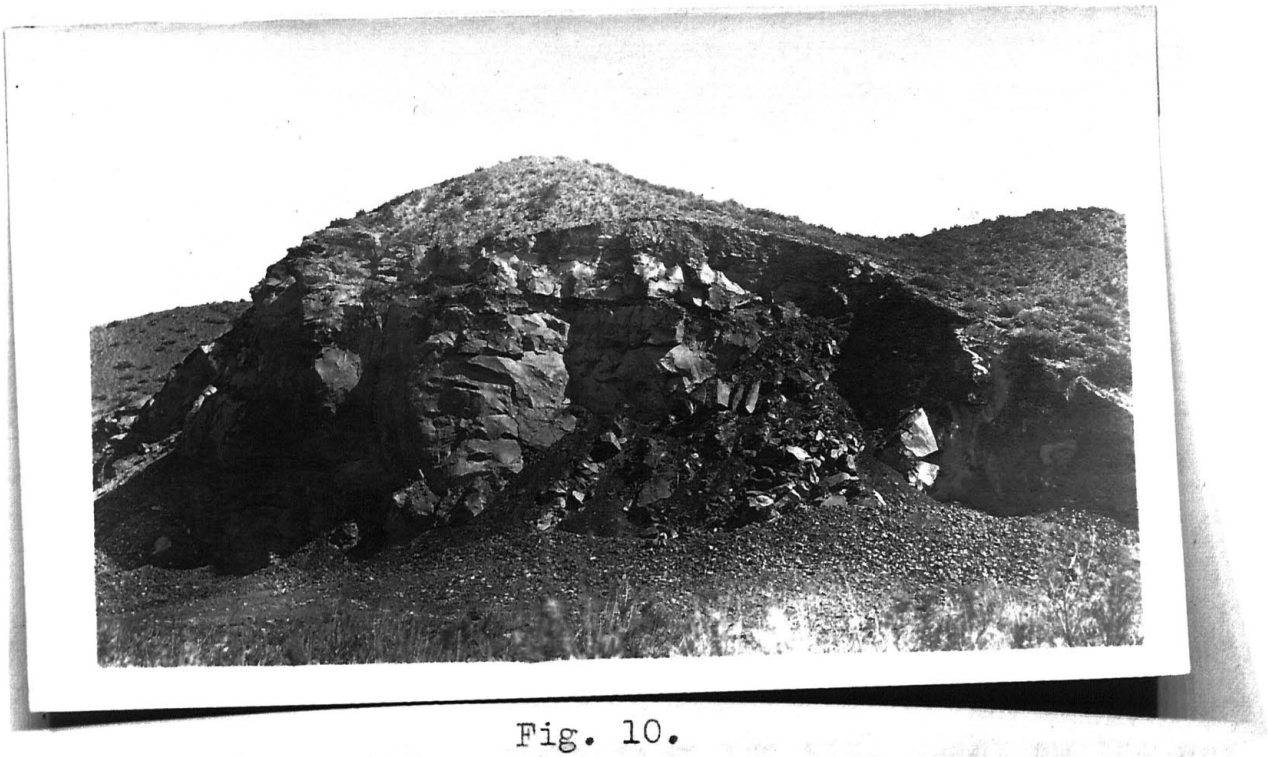

Fig. 10.

View taken May 16,1910 showing quarry where all stone was obtained.

Fig. 11.

View taken March 15,1910 showing protection to road fill at east abutment of bridge.

taken after they had been accepted by the Board of County Commissioners. (see pages 26, 28, and 30)

LABOR COST.

It took the contractor 82 days to complete his contract at the following expense for labor:

Common labor----------25 cents per hour.
Man and team---------- 50 " " "
Powder foreman ---------- 75 " " "
Superintending ---------- 60 " " "

Superintending the contract amounted to 1369 hours @ .60 = 821.40 .This represents the time spent on the work by the contractors, two brothers, and is charged to various labor items in the following table.

Brush.

Cutting and binding into bundles 1575 hrs.@ .25=		393.75
Superintending ----------		75.00
		468.75
Hauling brush --- 369 hrs.@ .50=	184.50	
Superintending ----------	75.00	259.50
Total labor cost of brush delivered ------		728.25

Stone.

Quarrying and loading wagons 4224 hrs.@ .25 =		1056.00
Powder foreman ---------- 769 " @ .75 =		576.75
Superintending ----------		75.00
		1707.75
Hauling ------ 2392 hrs.@.50=	1196.00	
Superintending ----------	75.00	1271.00

Fig. 12.

View taken March 14,1910 looking east from bridge abutment showing wagon unloading stone,and the earth fill road.

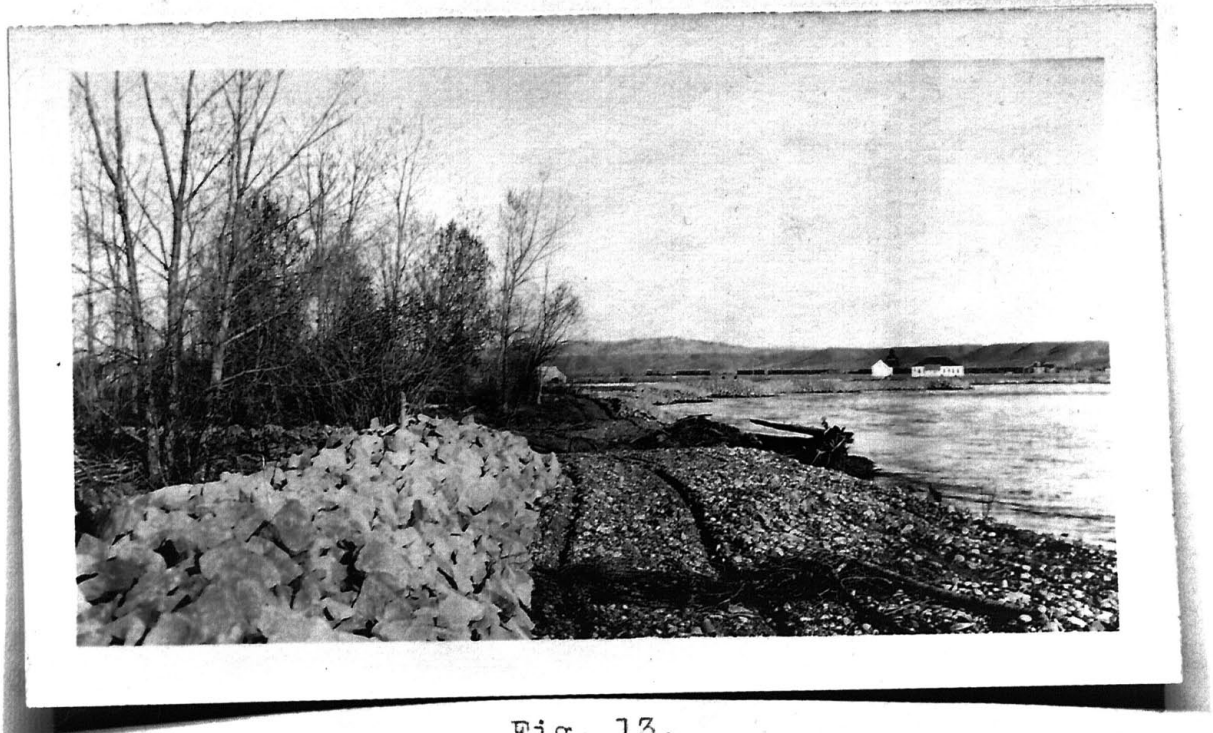

Fig. 13.

View taken May 3,1910 looking east along dike across slough showing protection works in the distance.

Total labor cost of stone delivered ----			2978.75
Sloping Banks & Placing Materials.			
Wing-dam No.5	513 hrs.@ .25=128.25		
	Superintending 100.00		
		228.25	
Wing-dam No.1	189 hrs.@ .25= 47.25		
	Superintending 35.00		
		82.25	
Wing-dam No.2	243 hrs.@ .25= 60.75		
	Superintending 50.00		
		110.75	
Wing-dam No.3	414 hrs.@ .25=103.50		
	Superintending 85.00		
		188.50	
Wing-dam No.4	378 hrs.@ .25= 94.50		
	Superintending 75.00		
		169.50	
Bank Slopes	525 hrs.@ .25=131.25		
	Superintending 106.40		
		237.65	
Total labor cost of sloping and placing materials in Wet Work		1016.90	
Dry Work	286 hrs.@ .25= 71.50		
	Superintending 70.00		
Total labor placing materials Dry Wk.		141.50	
Total labor sloping and placing materials			1158.40

Fig. 14.

View taken Mar.5,1910 showing ice jamb,Huntley in distance.

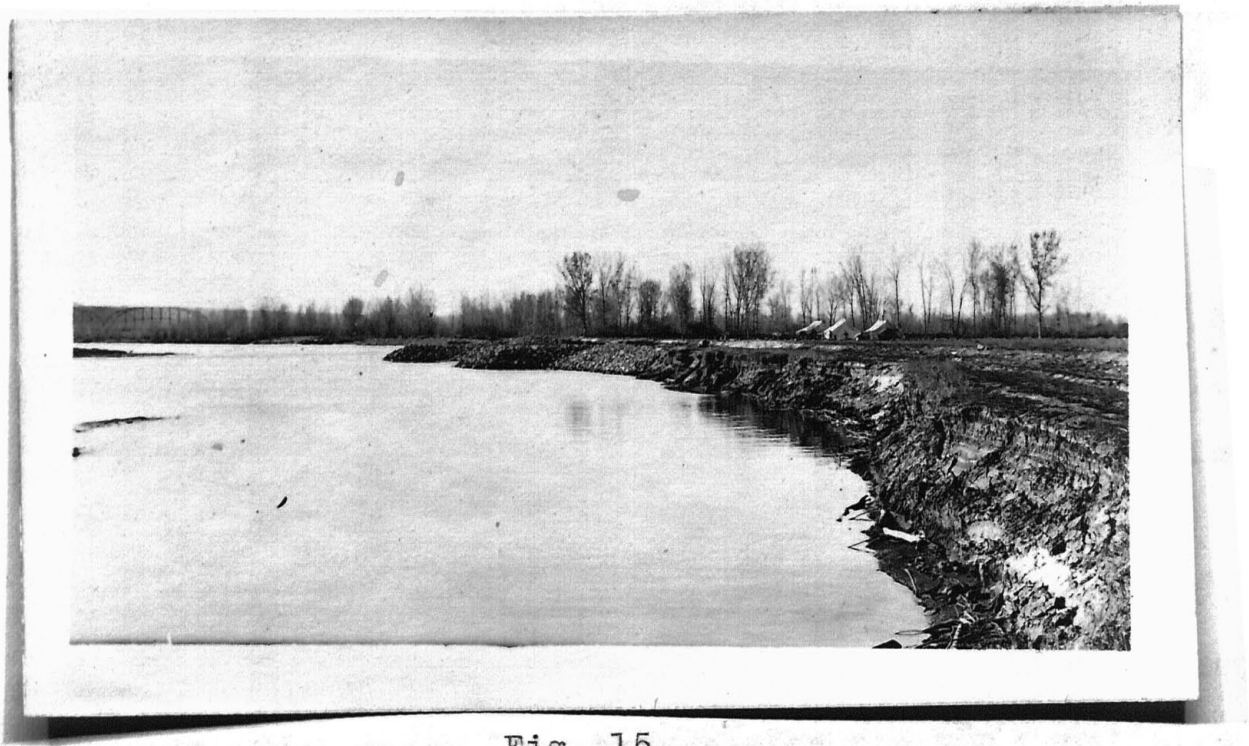

Fig. 15.

View taken May 3,1910 from above protection works showing condition of natural cut bank,protection works in distance.

Total labor cost charged to contract 4865.40 150.00 is charged to labor of sloping banks. Deducting this 150.00 from 1016.90, the labor cost of sloping banks and placing materials in Wet Work, 866.90 is the amount of labor in placing materials in Wet Work.

QUANTITIES OF STONE AND BRUSH.

	Brush	Stone	Total cu.yds.
Wing-dam No.5	152.0	164.6	316.6
Wing-dam No.1	123.2	147.8	271.0
Wing-dam No.2	142.3	247.0	389.3
Wing-dam NO.3	208.4	261.2	469.6
Wing-dam No.4	172.6	326.0	498.6
Bank slope	407.7	587.8	995.5
Total Wet Work	1206.2	1734.4	2940.6
Dry Work	187.0	358.2	545.2
Totals	1393.2	2092.6	

STONE.

The stone was quarried from a sandstone cliff (Fig.10 page 22) sixty feet high and about eighty-five hundred feet from the works making the haul about one and two thirds miles. The roads were good level dirt roads, the hardest point being the railroad crossing which is a raise of about four feet. Each wagon load was weighed and the quantities of stone figured from these weights. Several samples of the stone were carefully weighed and found to run on an average of onehundred and forty pounds to the cubic foot. The cost

Fig. 16.

View taken May 3,1910 from wing-dam No.2 showing Nos.3,4,& 5.

Fig. 17.

View taken May 3,1910 from bank at 3rd.wing-dam showing 4th. wing-dam,bank protection,and in distance,the dike across slough:also shows winding road fill.

of stone to the contractor was as follows:

Labor quarrying and loading onto wagons ----		1707.75
1200 lbs.40% dynimite @ 17.50 per100#	210.00	
98 kegs of black powder @ 2.00 -----	196.00	
900 caps @ 1.00 per 100 ----------	9.00	
2000 ft.double tape waterproof fuse @ 6.10 per 1000ft. ----------	12.20	
Total cost of materials -------		427.20
Total cost of rock on wagons --		2134.95

2134.95/2092.6=1.02 per cu.yd.on wagons.

1271.00/2092.6=0.61 " " " for hauling.

1.63 " " " delivered

BRUSH.

The brush and poles were cut along the river and had to be hauled an average distance of about a mile. The brush was principally willows and was cut with axes. To hold each bundle tightly while it was being bound with wire, two sticks two feet long and two inches in diameter with a chain eighteen inches long connecting them were used. By putting the chain under a bundle of brush, then raising and crossing the two sticks over the top of the bundle, one man compressed the brush while another put a wire around it and tightened with pliers. Baling wire was used for this purpose because it comes in such handy form to handle and of such length that each bailing wire makes three ties, just the number required for a bundle of brush.

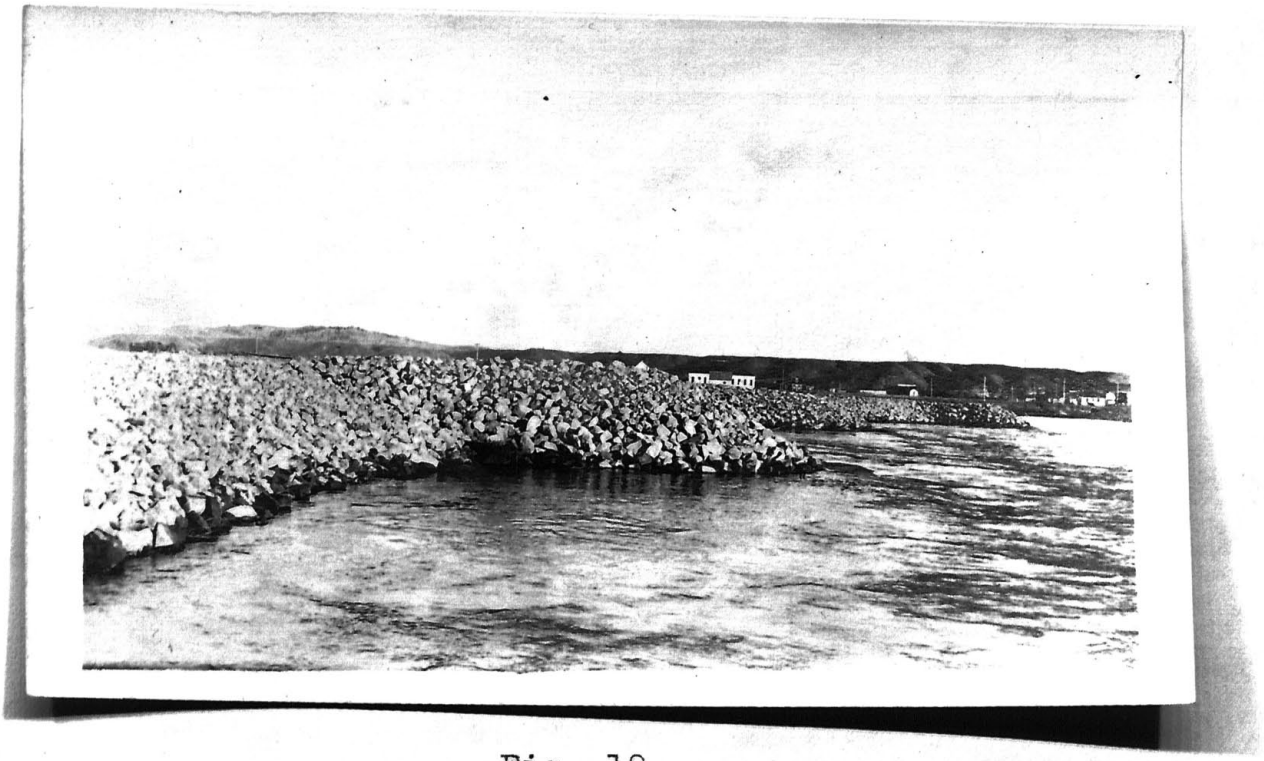

Fig. 18.

View taken May 3,1910 looking up stream from wing-dam No.5 showing wing-dams No. 4, 3, and 2.

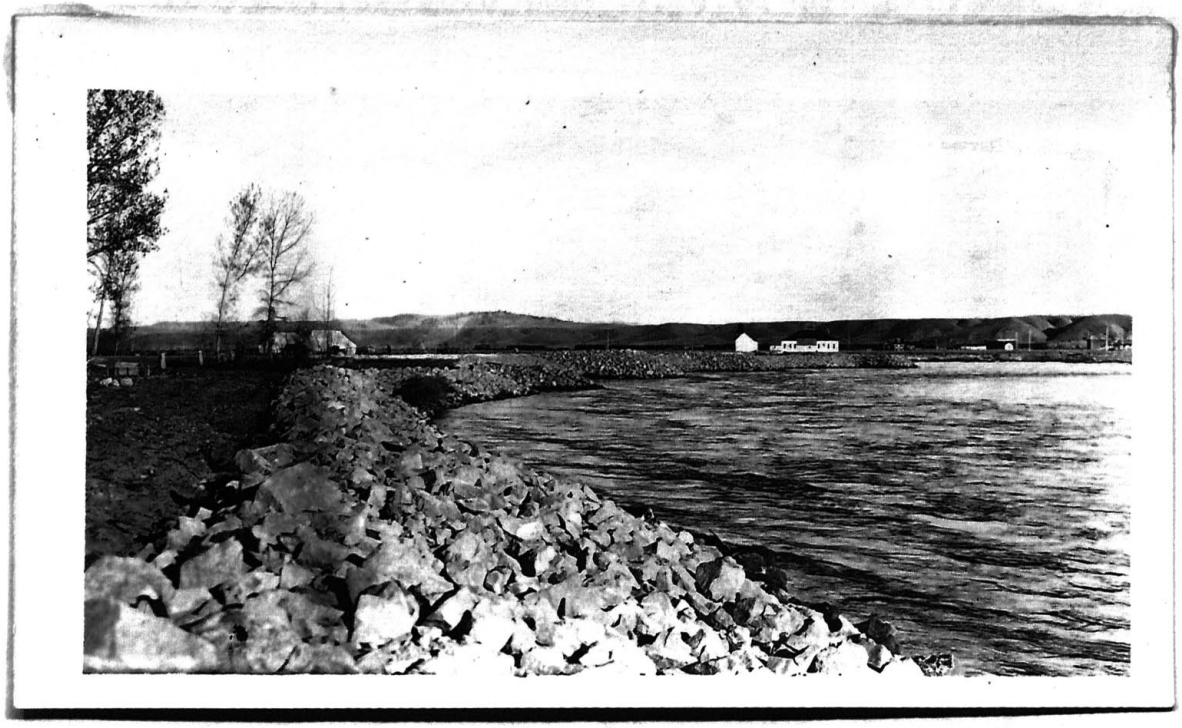

Fig. 19.

View taken May 3,1910 looking up stream from lower end of works showing general view of finished protection works.

The dimensions of each load of brush were taken as it came onto the sight of the work and from them were obtained the total quantities of brush. The brush cost the contractor as follows:

Labor cutting and tieing --- 468.75

(@ 2.25 per)22 bundles of bailing wire - 49.50

518.25

518.25/1393.2=0.37 per cu.yd.cut and bound.

259.50/1393.2=0.19 " " " hauling.

0.56 " " " delivered.

UNIT COSTS TO CONTRACTOR.

500 lbs.of wire @ 4½¢= 22.50 to placing brush.

22.50/1393.2=0.016 per cu.yd.of brush placed.

Wet Work.

866.90/2940.6=0.295 per cu.yd. placing materials.

150.00/598.3=0.25 per cu.yd. SLOPING.

1.63 per cu.yd.stone delivered.

0.295 " " " placing

1.925 " " " STONE IN PLACE.

0.56 per cu.yd.brush delivered.

0.295 " " " labor for placing brush.

0.016 " " " material " "

0.87 " " " BRUSH IN PLACE.

Dry Work.

141.50/545.2=0.26 per cu.yd.placing materials.

1.63 per cu.yd.stone delivered.
0.26 " " " placing stone
1.89 " " " STONE IN PLACE.

0.56 per cu.yd.brush delivered.
0.26 " " " labor placing brush.
0.016 " " " materials " "
0.836 " " " BRUSH IN PLACE.

COSTS TO COUNTY AND PROFITS TO CONTRACTOR.

2940.6 cu.yds.Wet Work @ 2.65 ----- =		7792.59
598.3 cu.yds.earth excavated @ .50 =		299.15
545.2 cu.yds.Dry Work @ 2.20 ------ =		1199.44
Total cost to the county		9291.18
Total labor ----------	4865.40	
Materials quarrying	427.20	
Wire preparing brush	49.50	
" placing brush	22.50	
Total cost to contractor		5364.60
Profit to contractor		3926.58

APPENDIX.

COST OF CLEARING ICE JAMB.

The ice jamb referred to in the foregoing article threatened, for a while, to be very serious. It raised the river above high water mark and ran over the road fill for some time. The river was frozen over solid for a half mile above and a half mile below the bridge with the exception of a short channel, sixty by two hundred feet, at the west end of the bridge. Above this solid sheet of ice, the floating ice jambed for a mile.

Beginning at the little open spot at the bridge, a channel fifty feet wide was shot out up to the jamb. After this channel was made, several large shots were put in the jamb before it gave away. A battery was used to shoot with the last day and proved to be much more effective as well as safer. Forty percent dynimite was used. The cost was as follows: common labor at 25¢ an hour, powder foreman 75¢, and man and team 50¢.

Labor-------	121.75
1650 lbs. of powder @ 17.50 ---	288.75
caps, fuse, and exploders -----	9.00
	419.50